

# Time Series Analysis

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# Overview

- **Time Series Data**
- **Time Series Analysis**
- **Uses of Time Series Analysis**
- **Intuition for Time Series Models**

# Time Series Data

- A collection of observations of a particular variable made chronologically.
  - Numerical
  - Same time intervals
  - Large in size
  
- Examples:
  - Monthly sales total, stock indexes, population census, Webster University enrollment, unemployment rate, daily temperature, etc.


# Bitcoin

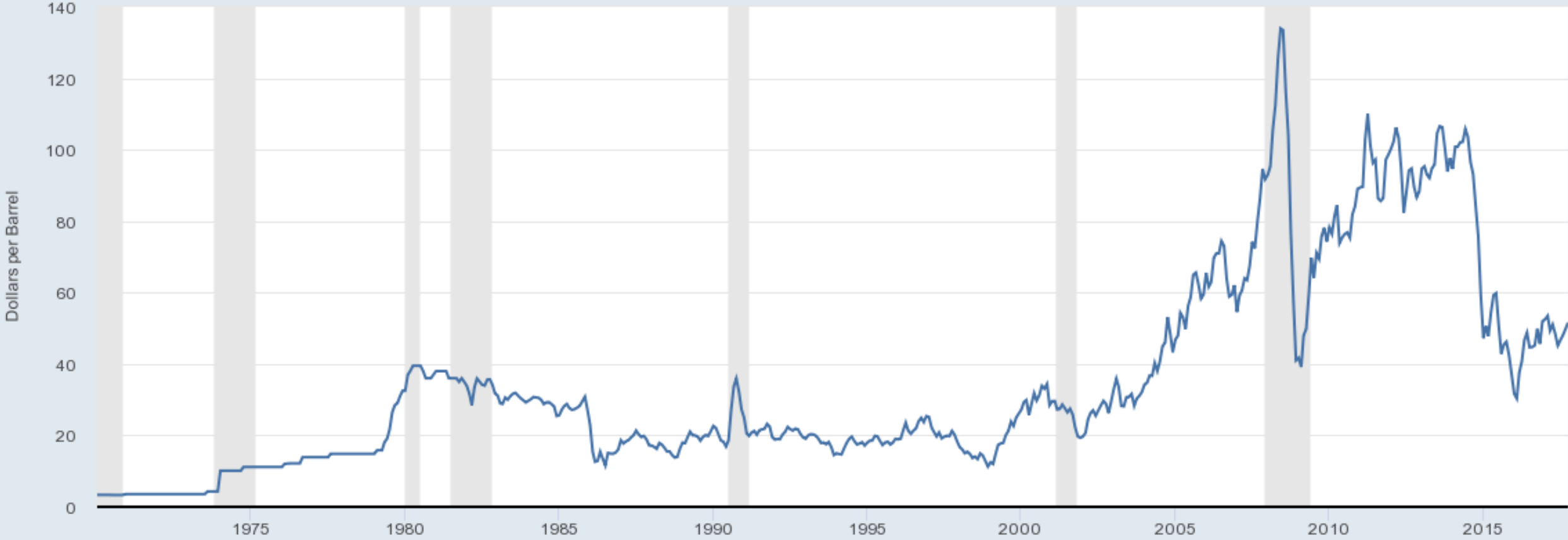
Market Price (USD)

source: blockchain.info



# Oil Price

**FRED**  — Spot Crude Oil Price: West Texas Intermediate (WTI)



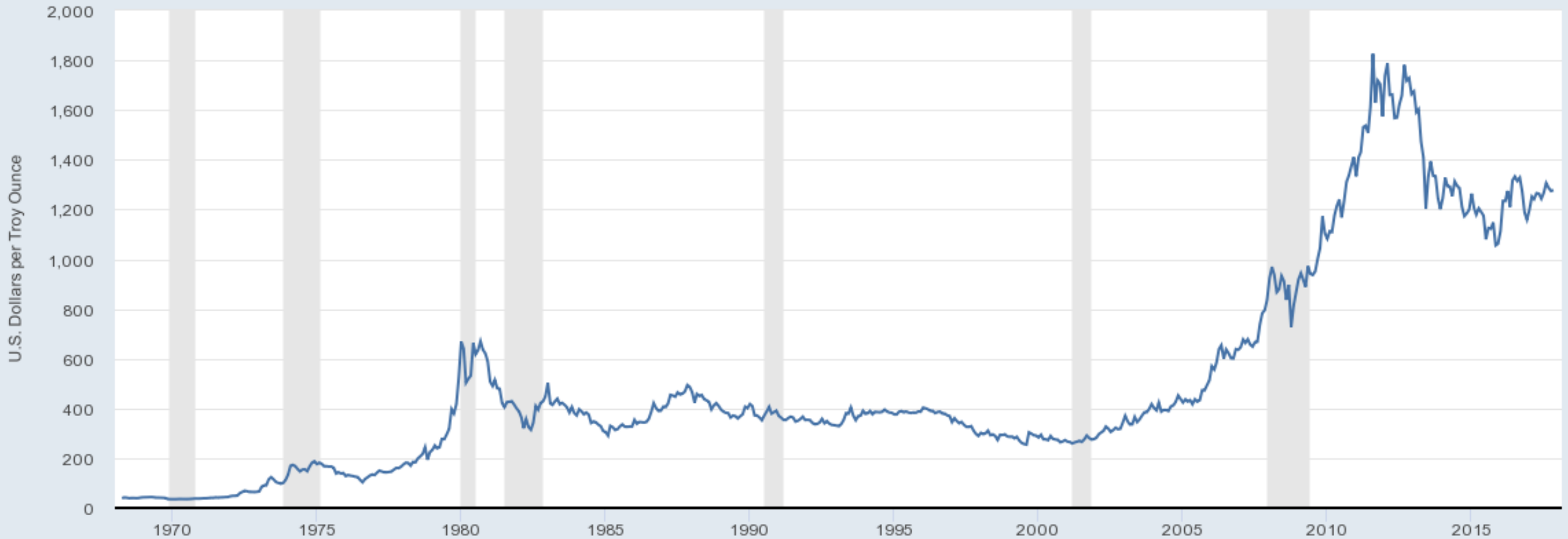
Shaded areas indicate U.S. recessions

Source: Federal Reserve Bank of St. Louis

[myf.red/g/fLai](https://myf.red/g/fLai)

# Gold Price

**FRED**  — Gold Fixing Price 10:30 A.M. (London time) in London Bullion Market, based in U.S. Dollars



*Shaded areas indicate U.S. recessions*

Source: ICE Benchmark Administration Limited (IBA)

[myf.red/g/FLak](https://myf.red/g/FLak)

# Uses of Time Series Analysis

- **Description** (monitoring data)
  - Describe patterns over time
- **Explanation**
  - Can the pattern be explained by other factors? Helps understand behavior of the series
- **Forecasting** (prediction of future value)
  - Can past records help us predict the future?
- **Improving** past behavior
  - If factors affecting the behavior of a variable over time can be identified, action may be taken to improve the system, e.g. action over increasing levels of air pollution
- **Predicting** a future event
  - Business decisions for production, inventory, personal, etc.

# Time Series Analysis

- **Methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.**
  - Interpretation
  - Forecasting
  - Hypothesis testing
  - Trend analysis
  - Control (response)
  - Simulations
- **Fields: economics, finance, geology, meteorology, business, biology, etc.**



# Time Series

- Observations taken at specific points in time: Discrete Time Series
  - annual number of car accidents (discrete)
  - maximum daily temperature (continuous)
  - whether or not there was daily rain (binary)

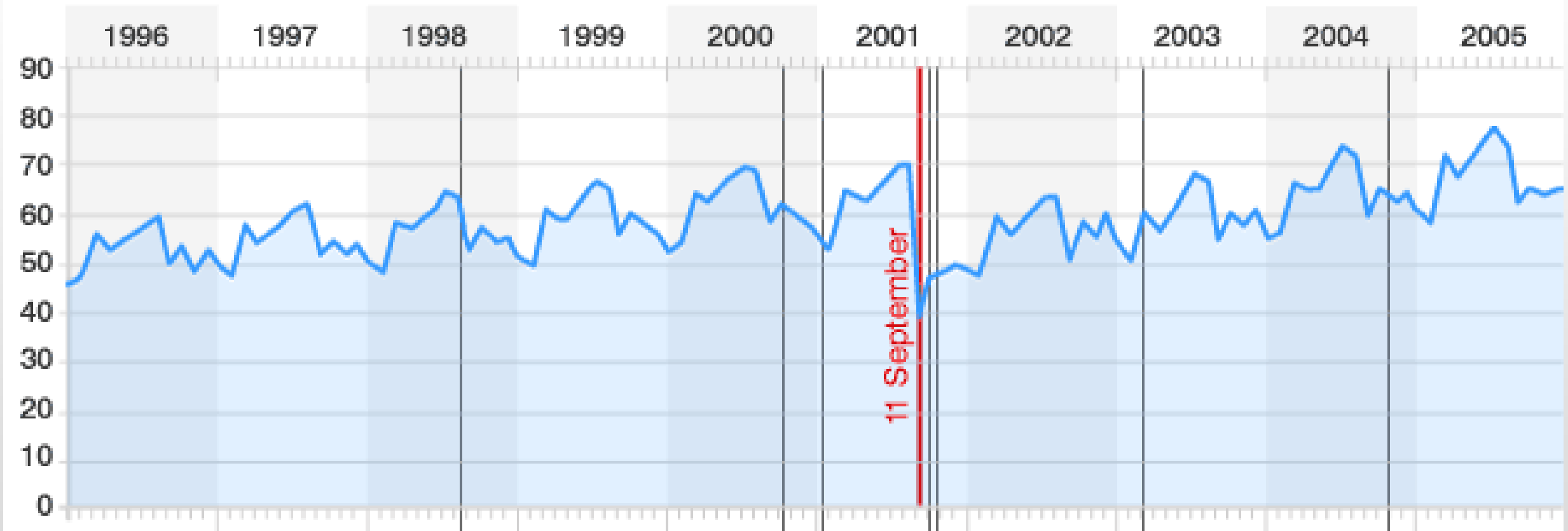
# Trend Analysis

- Sustained movements in the variable of interest in a specific direction. It can take the form of a linear trend analysis. The dependent variable changing at a constant rate over time.
  - Horizontal pattern (mean)
  - Trend pattern (upwards or downwards)
  - Season pattern (depending on weather, frequency of event, etc.)
  - Cyclical pattern (Up, down, up, ...)

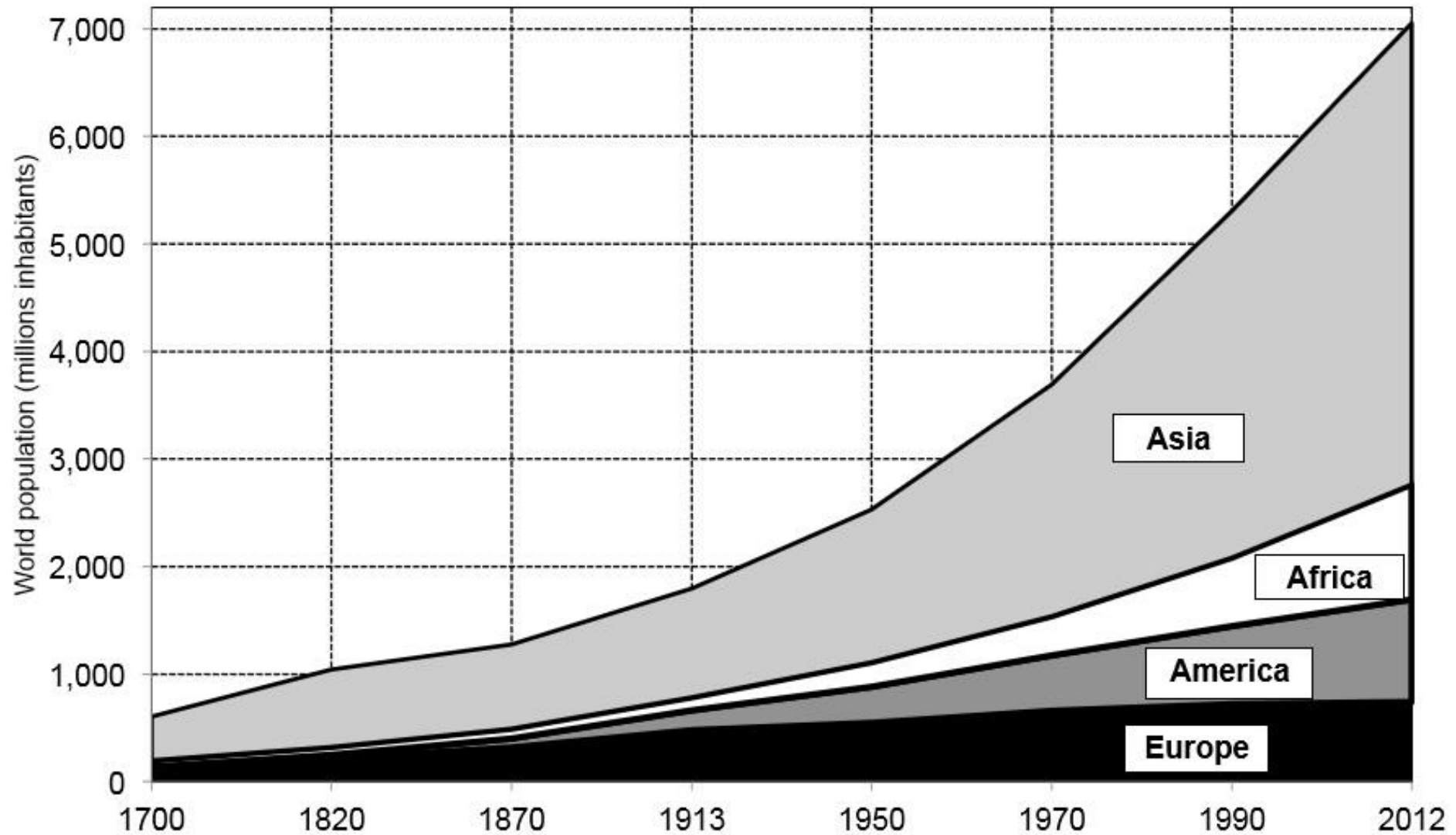
# Airline Passengers in the United States – 9/11 shock

PASSENGERS BOARDING FLIGHTS IN THE US, MILLIONS

SOURCE: Bureau of Transportation Statistics



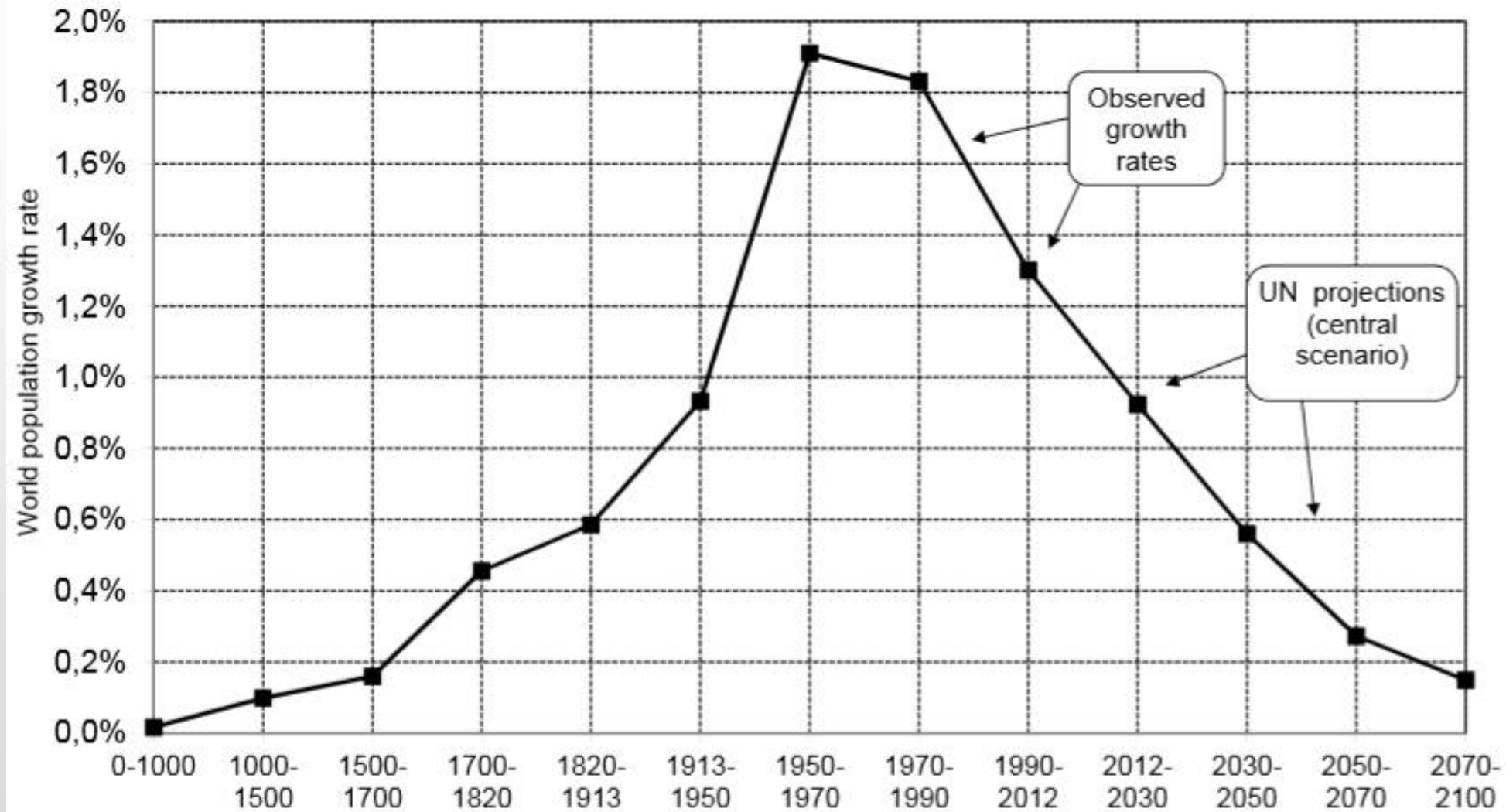
**Figure 2.1. The growth of world population 1700-2012**



World population rose from 600 million inhabitants in 1700 to 7 billion in 2012.

Sources and series: see [piketty.pse.ens.fr/capital21c](http://piketty.pse.ens.fr/capital21c).

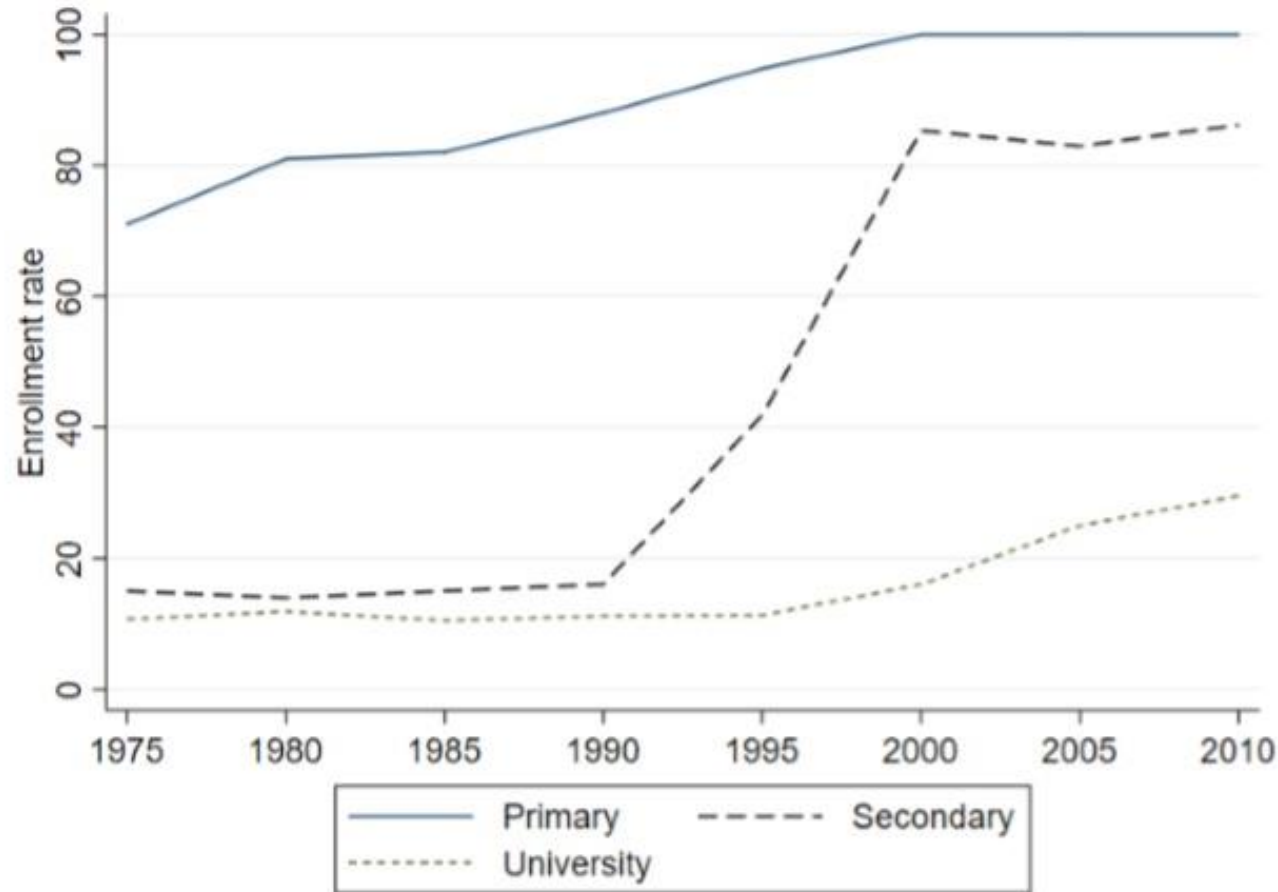
**Figure 2.2. The growth rate of world population from Antiquity to 2100**



The growth rate of world population was above 1% per year from 1950 to 2012 and should return toward 0% by the end of the 21st century. Sources and series: see [piketty.pse.ens.fr/capital21c](http://piketty.pse.ens.fr/capital21c).

Figure 1: Changes in enrollment rates in Brazil

(b) Historical comparison



Panel(b) shows the historical evolution of enrollment rates for primary, secondary and university education in Brazil. Enrollment ratios are defined as the ratio of students at a given level of schooling in the designated age group to the total population of that age group. Source: Barro & Lee (2013).

# Summary

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# References

Wikipedia (Nov 4, 2017). [https://en.wikipedia.org/wiki/Time\\_series](https://en.wikipedia.org/wiki/Time_series)

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